AFCI Transmutation Engineering Overview

Michael W. Cappiello

National Technical Director of Transmutation Engineering, AFCI

Program Manager, Los Alamos National Laboratory

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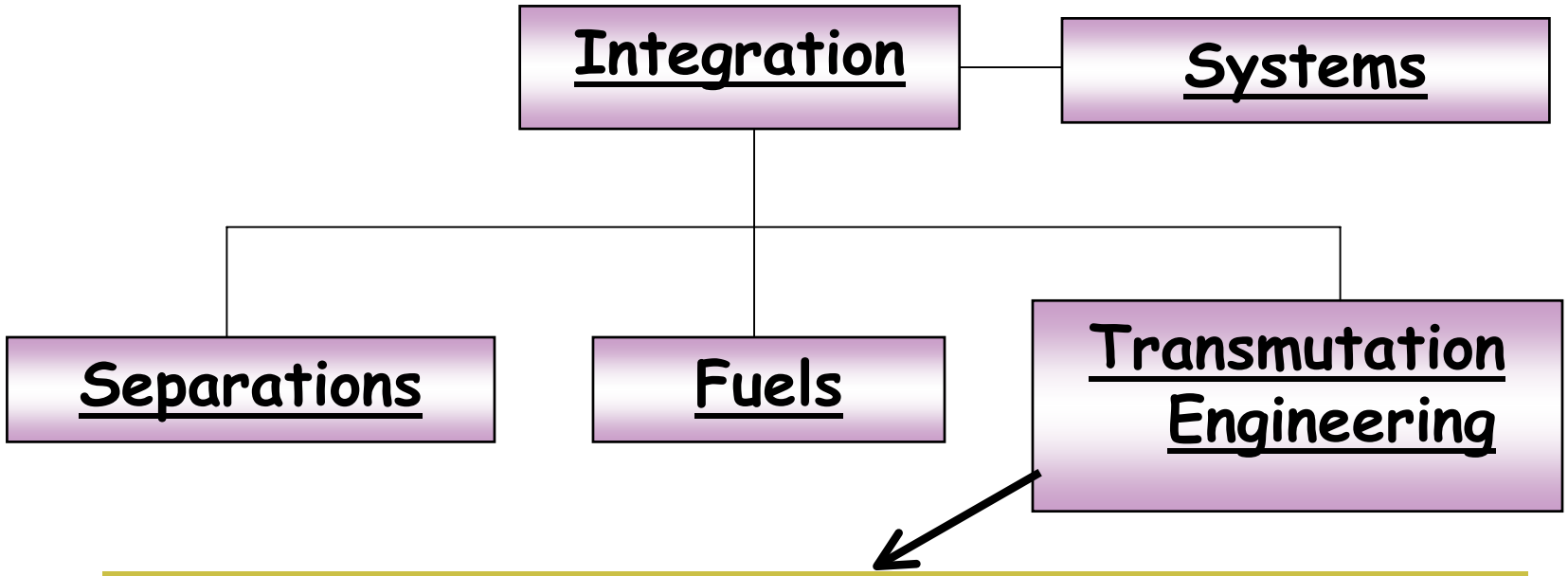
Outline

- Transmutation Engineering Objectives
- FY 2003 Highlights
- Future Activities

Transmutation Science provides the Engineering Basis Within AFCI



- **Develop engineering basis for the transmutation of Plutonium, Minor Actinides and long-lived fission products. Support for key program decisions:**
  - Fuel Cycle implementation strategy
  - Transmutation System Selection (GenIV Reactor, Transmuter Reactor, ADS)
  - GenIV, Reactor, ADS transmutation efficiency

To Address these Issues Transmutation Engineering is Organized into Three Research Areas

- Fuel Cycle implementation strategy
- Transmutation System Selection (GenIV, Reactors, ADS)
- GenIV, Reactor, ADS transmutation efficiency

Physics

- Nuclear data in thermal, epi-thermal and fast spectra
- Nuclear Safety data
- Codes and Models

Materials

- Structural material degradation during irradiation: material limits
- Lead-Bismuth Coolant, sensor technology and corrosion mitigation for fast spectrum reactor and ADS

ADS

- Coupling of accelerator to sub-critical reactor
- Operation and safety of ADS
- Target technology
- Accelerator Reliability

Transmutation Physics

- FY 2003 Highlights and Status
- Future Plans

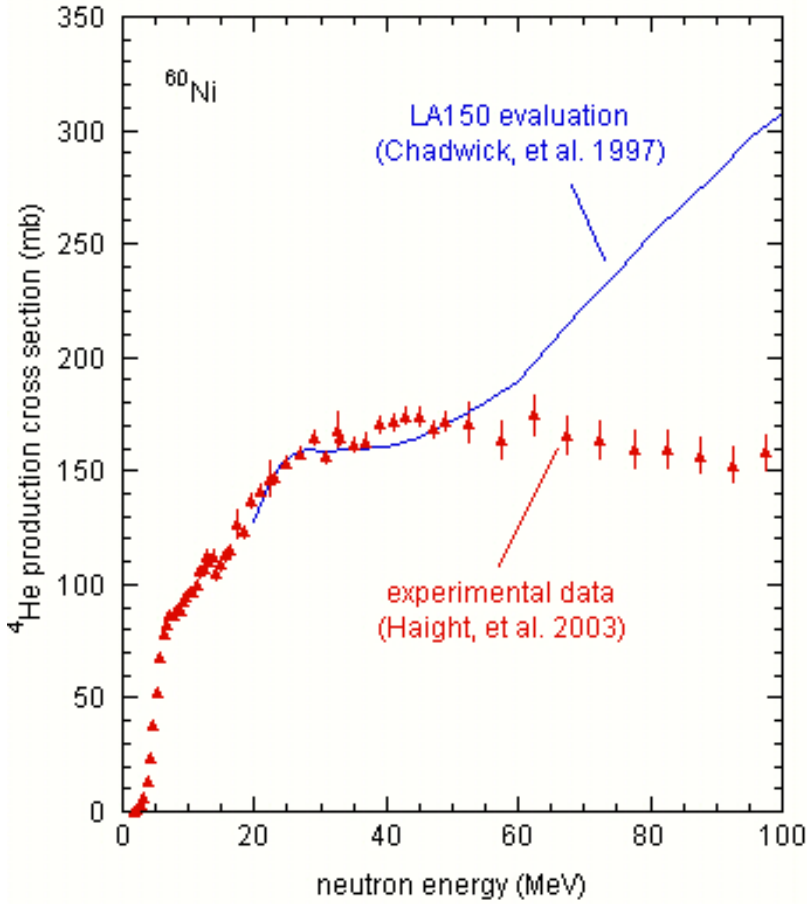
Transmutation Physics Highlights and Future Plans

FY2003 Highlights:

- Cugnon/Schmidt physics models incorporated in MCNPX
- Am-241 evaluation completed
- Neutron-induced He production data from nickel analyzed and published

Future Plans:

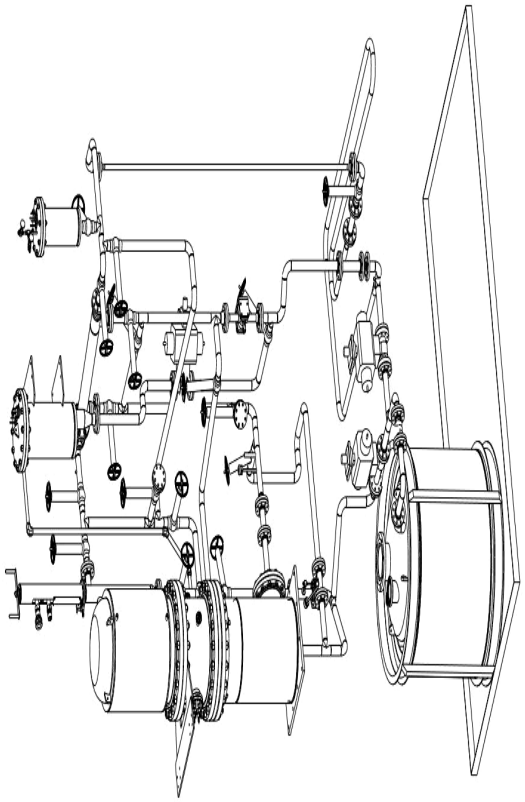
- Iron and Chromium gas production measurements
- Actinide fission and capture measurements and evaluations,
- Statistical and deterministic code improvements,
- Integral data analysis



Materials Coolant Technology

- FY 2003 Highlights
- Future Plans

LBE Technology Development is Centered at the DELTA Loop



Features:
- Test Bed for Component Development
- Removable Test Sections
- Natural Circulation

Lead Bismuth Advantages

- Non Reactive (leak safety)
- High Temperature Capability
- Natural Circulation (open lattice)
- Beneficial Physics (neutron economy)
- For both Reactor and ADS application

Highlights and Plans

- Loop Conditioning Removal Successful
- Oxygen Sensor Improvements Implemented
- Corrosion testing initiated
- Future Plans include long term corrosion tests and conversion to Lead

Structural Materials

- FY 2003 Highlights
- Future Plans

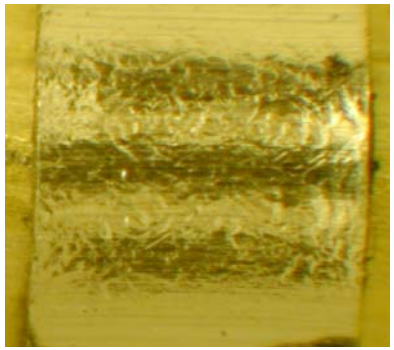
Structural Materials Research Relies on Archived Irradiated Samples, and Irradiations at PSI

FY 2003 Highlights

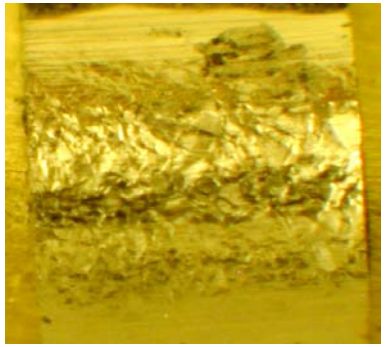
- Mechanical Testing and Microstructure of LANSCE, PSI irradiated samples.
- Data Evaluations published in Rev. 4 of Materials Handbook.
- Collaborations with TRADE and MEGAPIE
- Initiated the atomistic modelling of Helium in a Body-Center Cubic Iron matrix

Future Plans

- Will begin examination of specimens Irradiated in FFTF (Available in FY'04) and PSI
  - Doses up to 120 dpa

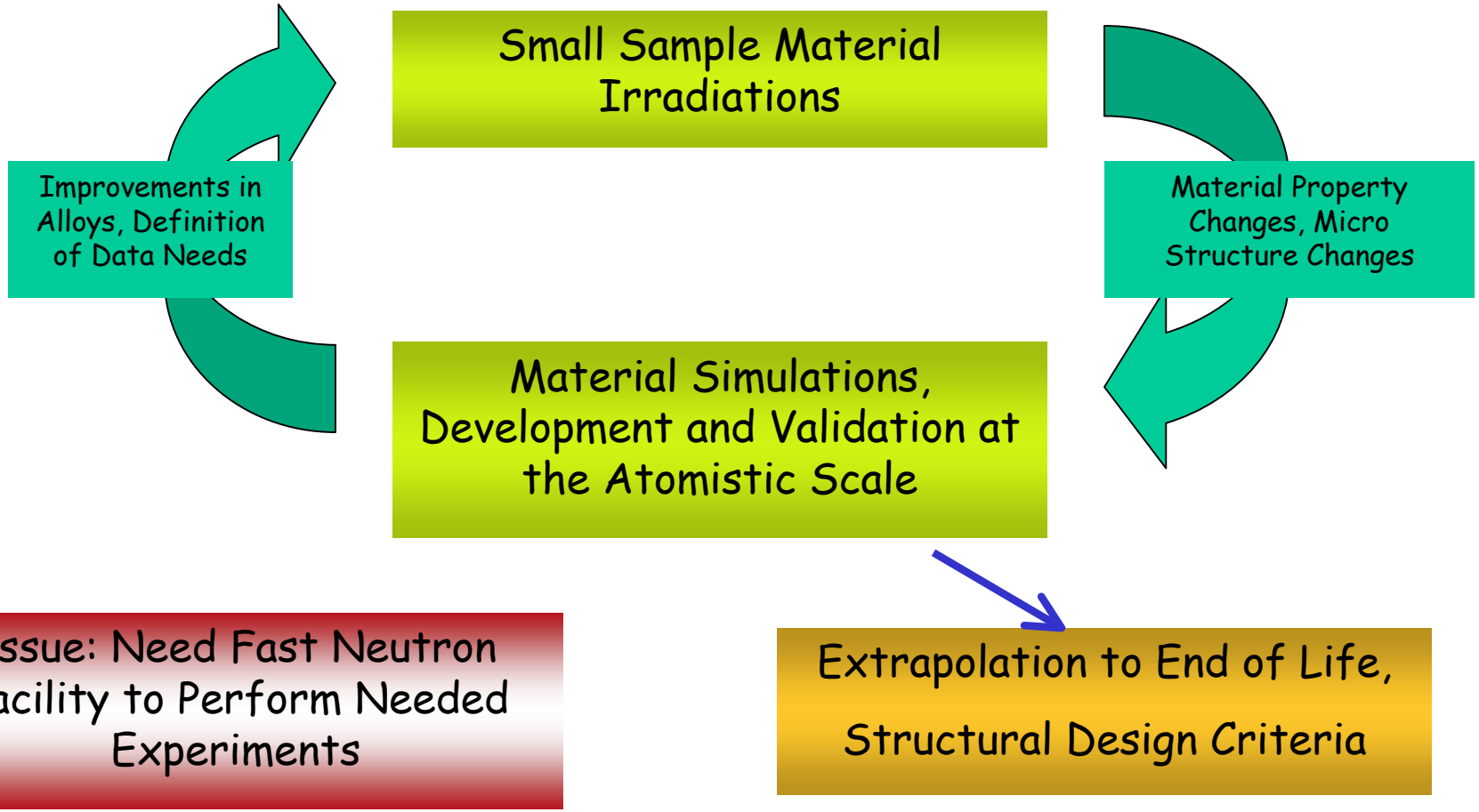


0 dpa
Mod 9Cr-1Mo

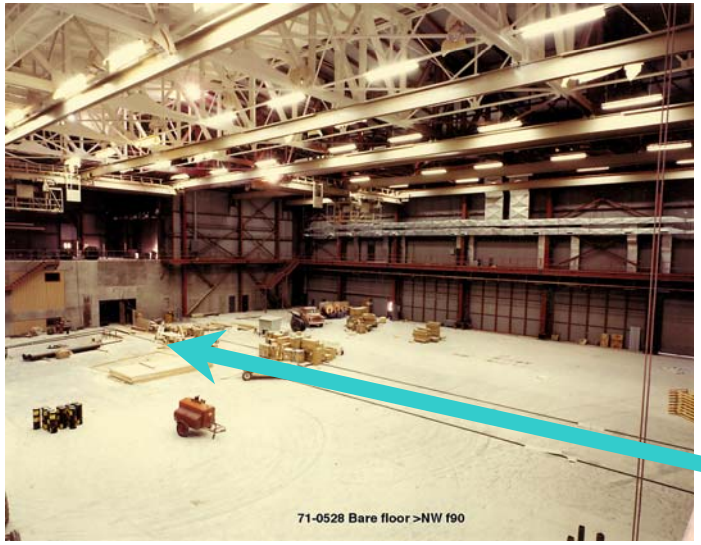


9.8 dpa
Mod 9Cr-1Mo

Research Approach to Structural Materials is one of Science Based Prediction: Irradiation Facility Needed



The Proposed Materials Test Station plus a Flux Booster in the ATR Provides the Necessary Fast Neutron Environment for Materials and Fuels

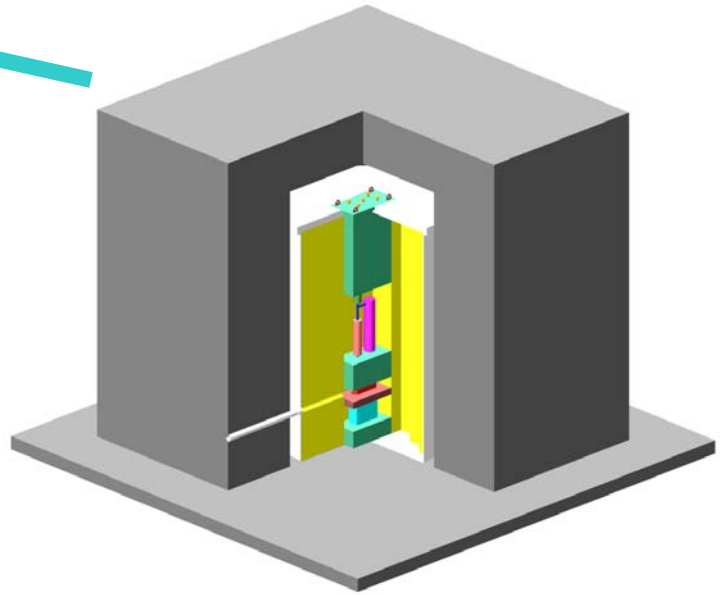


MTS Attributes

- **Intense fast spectrum neutron source** for development of AFCI transmuter and GenIV reactor materials.
- **Closed loops** for prototypic coolants and temperatures and "run to failure" capability.
- **Transient testing** for demonstration of off-normal conditions.

MTS Schedule

FY04	FY05	FY06	FY07	FY08
Installation/Commission				
			Operation/Testing	



Accelerator Driven Systems

- Role
- Issues
- Activities and Plans

The Role of ADS is to Complement Reactors in a Closed Fuel Cycle

Reactors are cheaper per unit of electricity produced.

ADS is cheaper per unit mass of TRU transmuted.

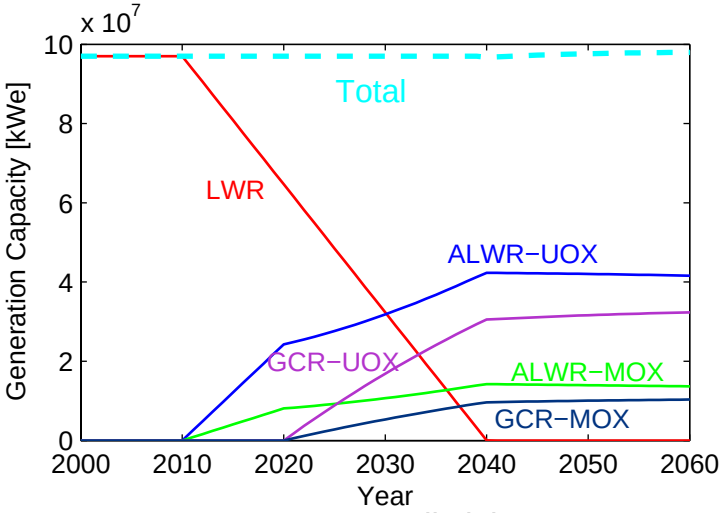
Reactor Issues:

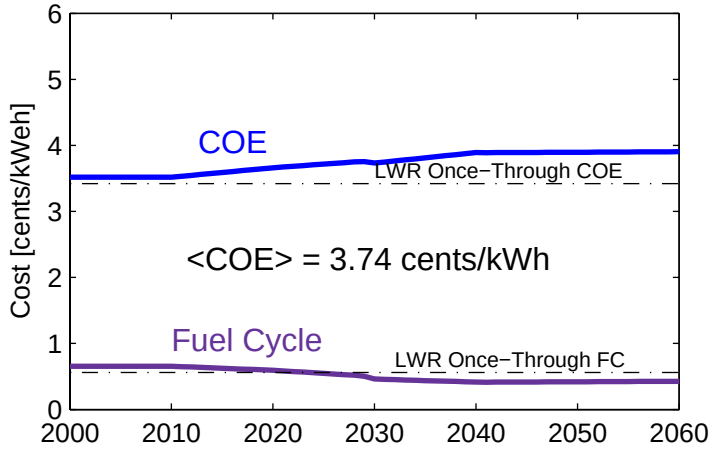
- LWR, ALWR, Gen IV Reactor Transmutation Role
  - Thermal Spectrum
  - Fast Spectrum
- Acceptable Conversion Ratio for Fast Spectrum System

ADS Issues:

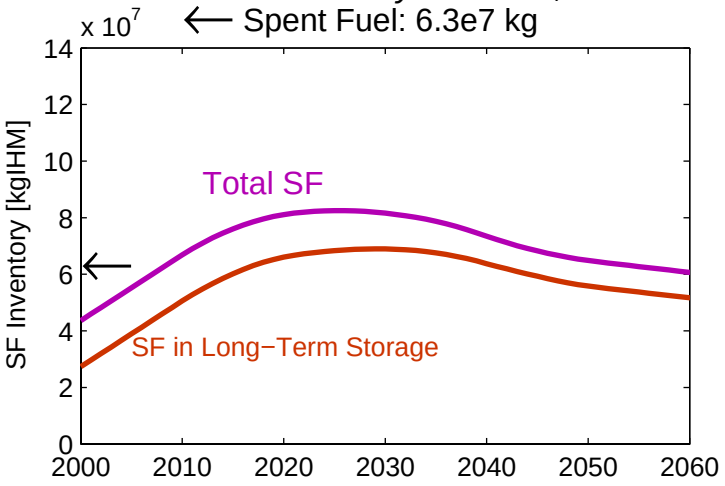
- Operation and Safety
- Reliability
- Target and Materials
- Cost

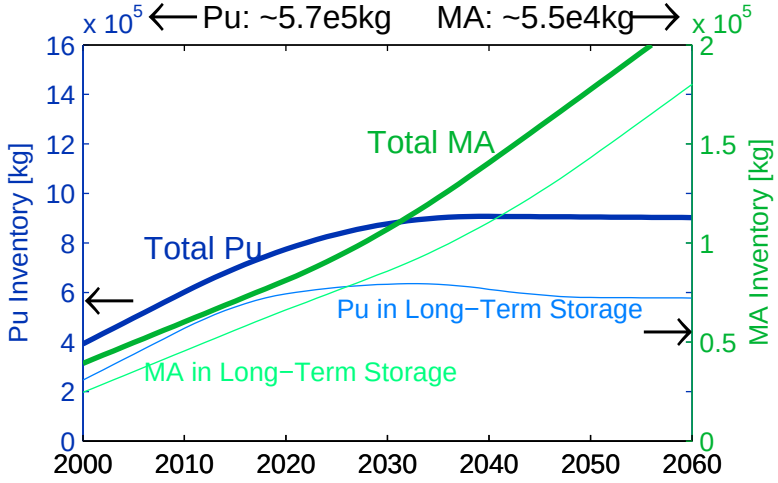
MOX Recycle Can Stabilize Pu Inventory, but Minor Actinides Accumulate



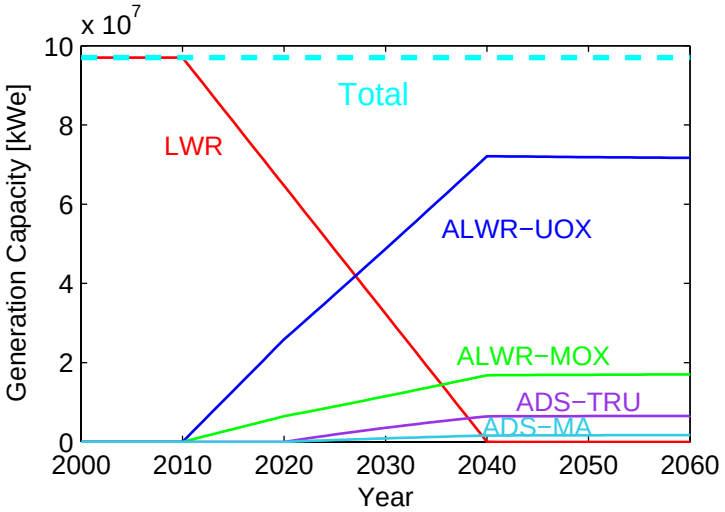


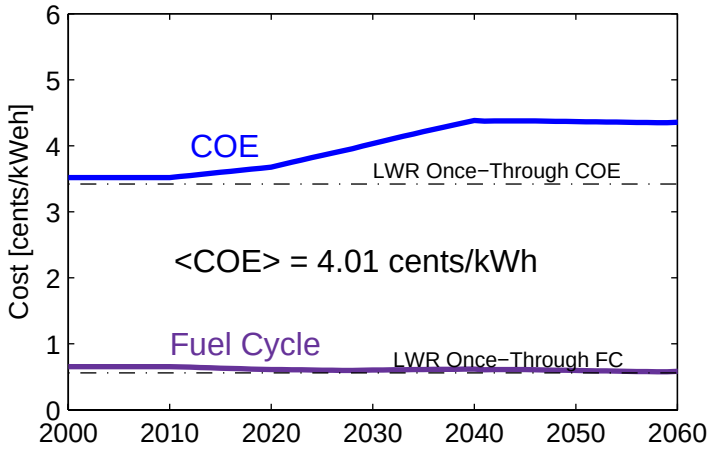
YM statutory limit is 63,000 MTIHM. For three LWR waste forms, this limit is:





Combine with ADS Treatment of SNF and Minor Actinides are Transmuted





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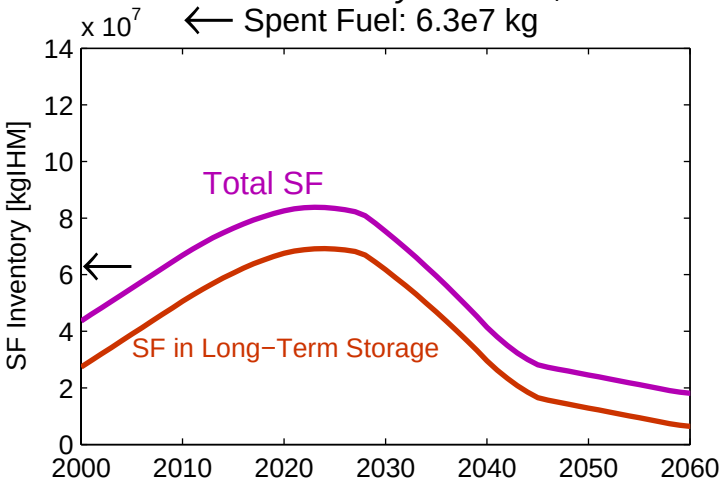
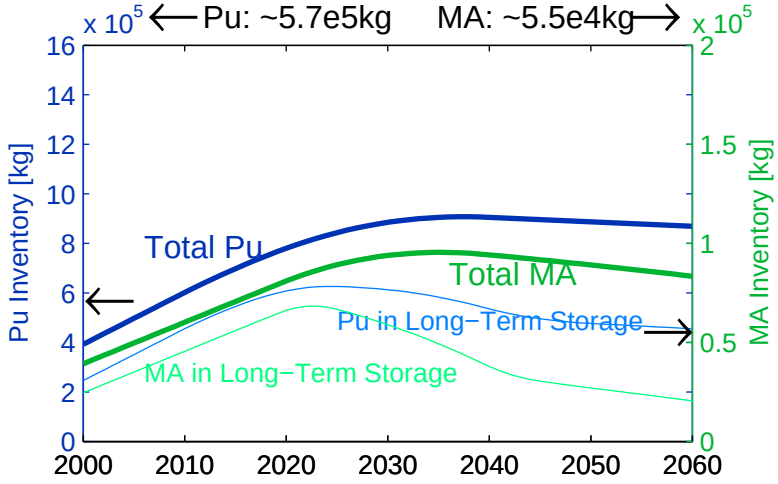




Accelerator Driven Systems Development is Driven by International and University Interest

Major International Projects are In Progress:

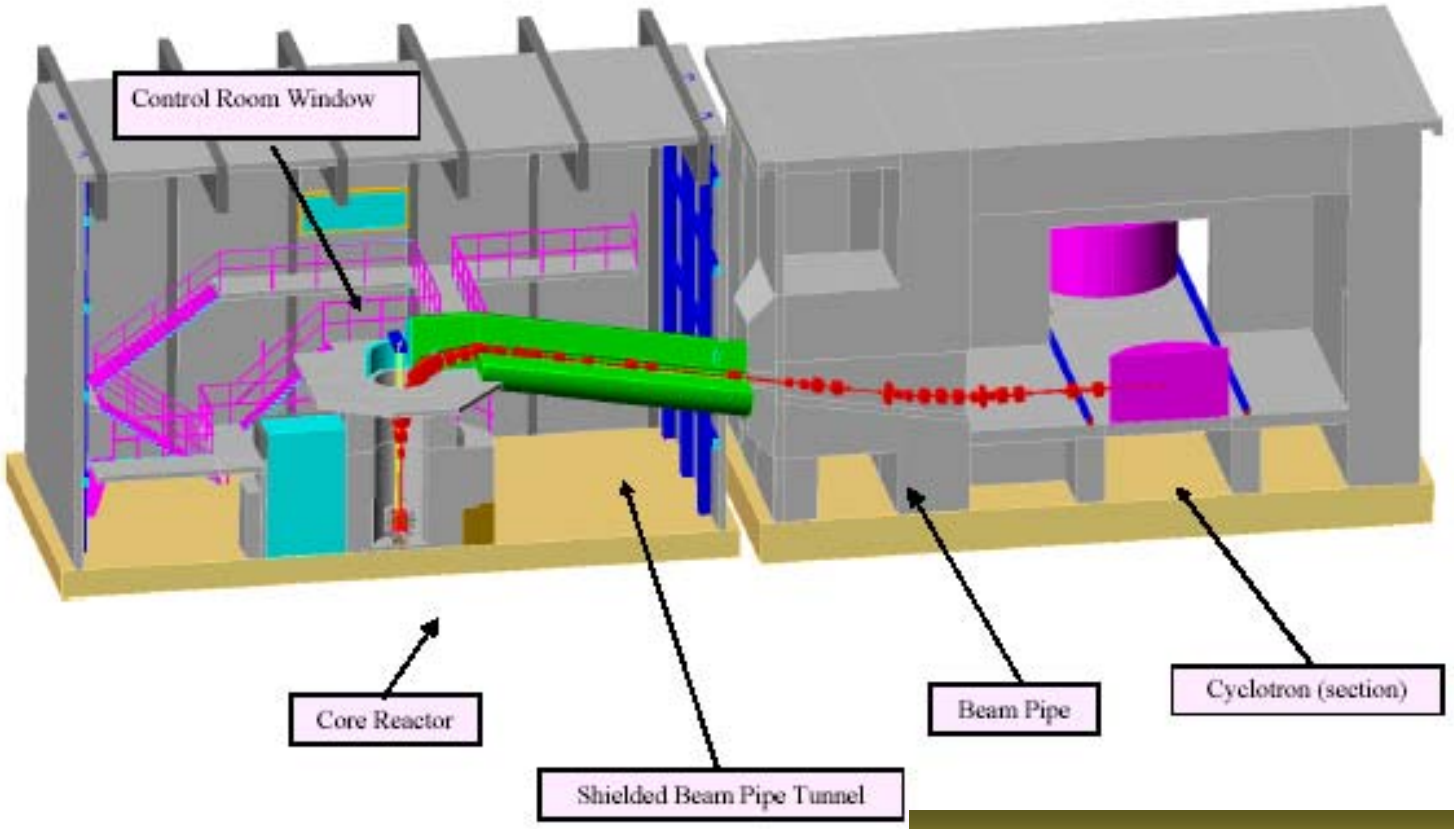
- MUSE: Coupled external sources to Fast Reactor Critical Facility (CEA-Cadarache)
- TRADE: Coupled Cyclotron to TRIGA Reactor in Italy
- MEGAPIE: Megawatt scale spallation source at PSI
- JPARC: Target Test Station and Low Power Sub-Critical Multiplier as part of Accelerator Complex
- Advanced Cavity Development at CEA-Saclay

One US Project in Planning Stage:

- Coupled electron accelerator (Idaho State) to TRIGA (U-Texas and Texas A&M)

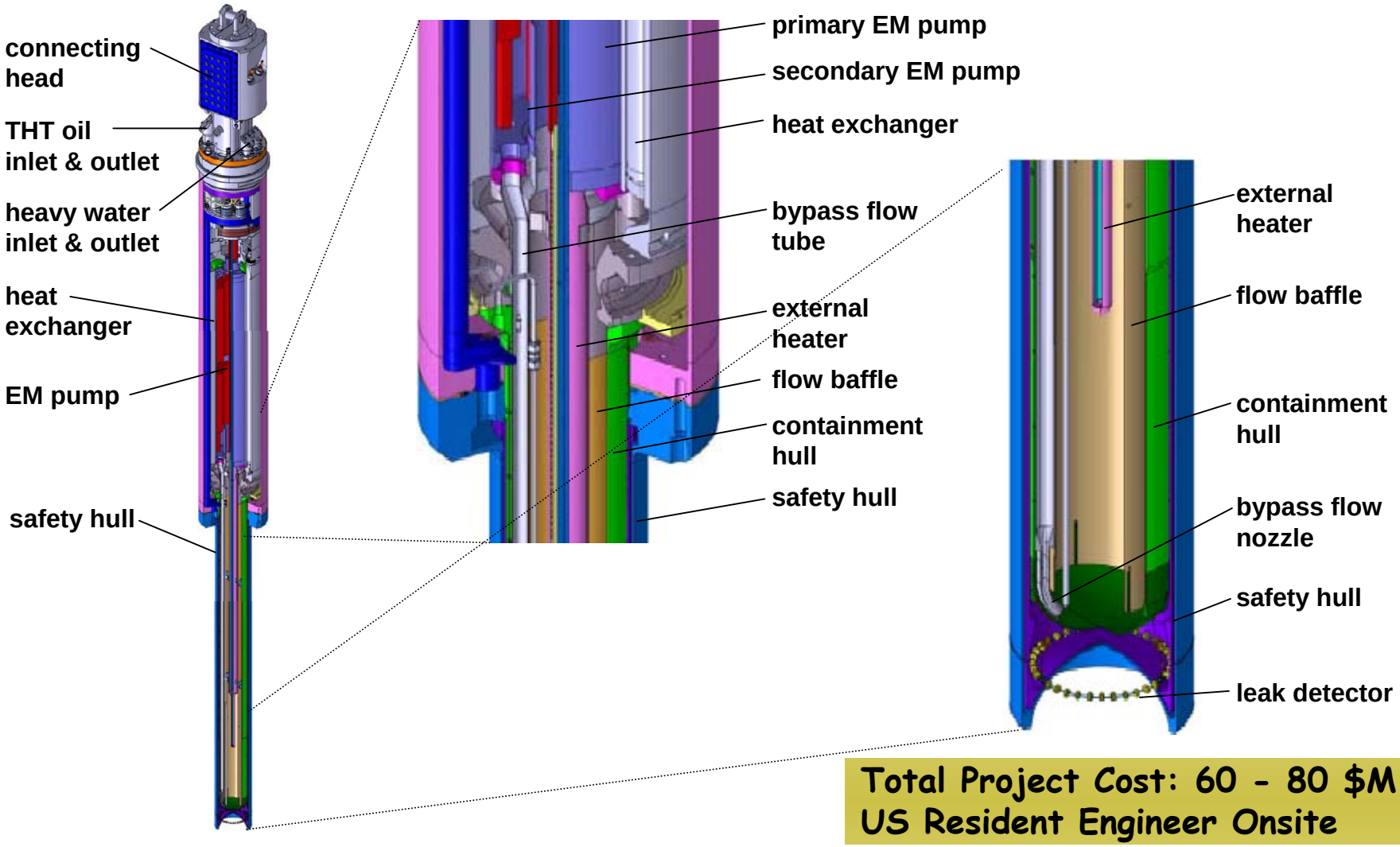
US participation in international ADS projects is critical for maintaining expertise in this area

TRADE Will Provide Coupled System Data at Power



Project Cost: $ 75M
US Resident Engineer Onsite

The MEGAPIE project will demonstrate a lead-bismuth spallation target at the Paul Shearer Institute in 2005

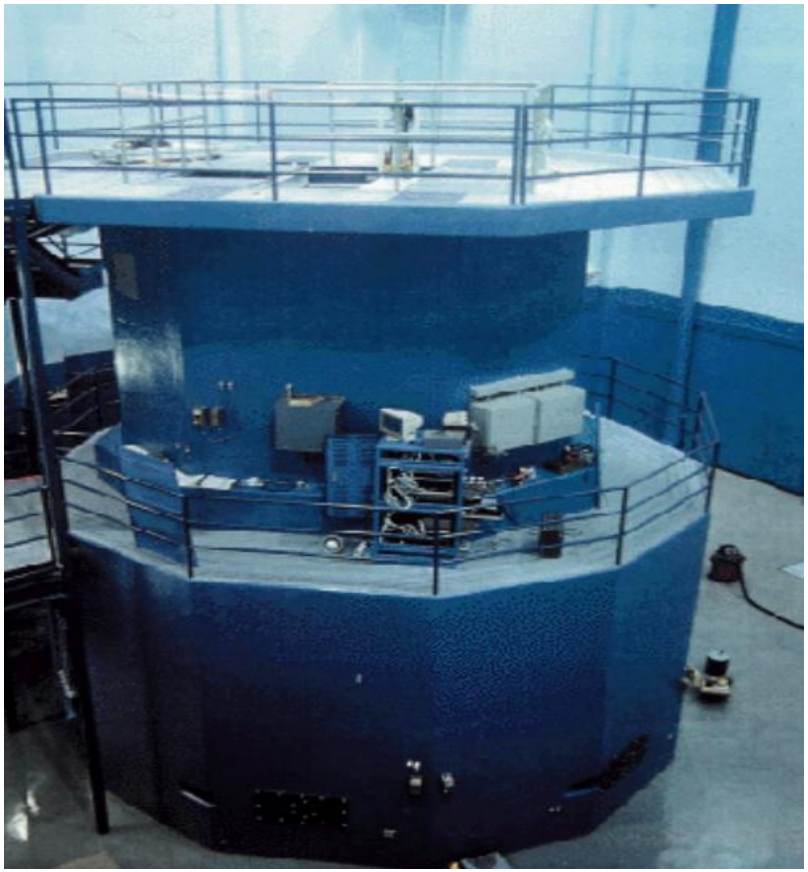


Total Project Cost: 60 - 80 $M
US Resident Engineer Onsite

Coupled Accelerator-Multiplier Experiments are planned by IAC, UT, and TAMU

- IAC will provide an Electron accelerator that can produce $1x10^{12}$ n/s thru gamma,n reactions.
- This will be coupled to thru an existing beam port to one of several reactors available.

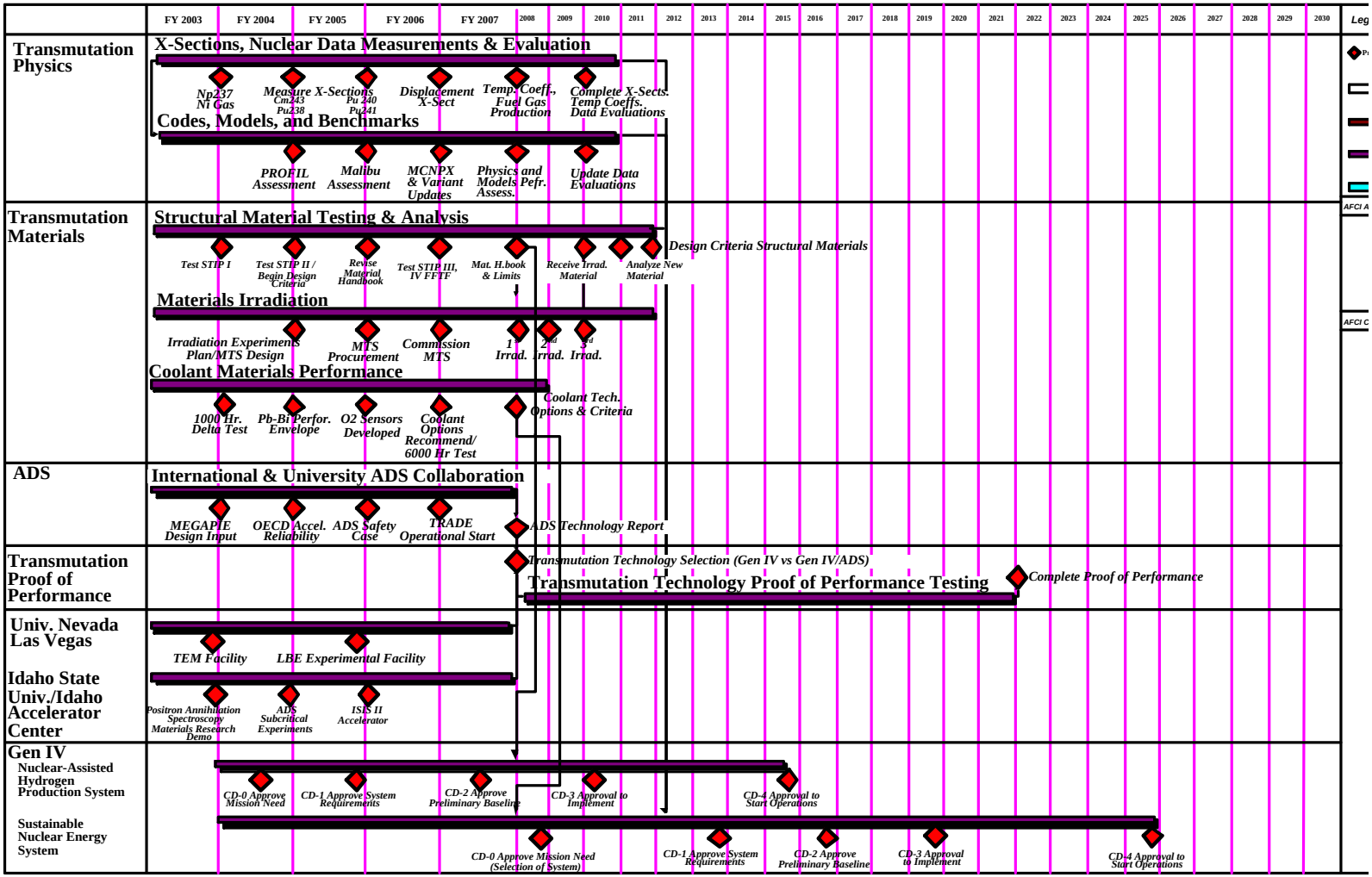
1 MW TRIGA Reactor at the University of Texas



- Provides complementary information to the TRADE experiment
- Provides an excellent training facility for students

Activities are Coordinated with 2007 Decision and Generation IV Needs

Advanced Fuel Cycle Initiative - Transmutation Engineering



Summary

- Transmutation Engineering plays an important role in AFCI and provides technical basis for transmutation.
- ADS is an important option and will complement reactor-based transmutation of Plutonium and Minor Actinides.
- Small scale experiments and modeling plays a fundamental role in large scale and end of life predictions.
- Research needs are extensive and will be accomplished thru National Labs and International and University collaborations.